[COMMITTEE PRINT]

REVIEW OF THE ANNUAL REPORT ON THE FEDERAL RESEARCH AND DEVELOPMENT PROGRAM—FISCAL YEAR 1976

SPECIAL OVERSIGHT REPORT NO. 1

SUBCOMMITTEE ON
DOMESTIC AND INTERNATIONAL
SCIENTIFIC PLANNING AND ANALYSIS

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
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LETTER OF TRANSMITTAL

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, D.C., April 27, 1976.

Hon. OLIN E. TEAGUE,
Chairman, Committee on Science and Technology,
House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: I am glad to submit to you our Subcommittee's Special Oversight report on the review we have conducted of the "Annual Report on the Federal Research and Development Program, Fiscal Year 1976."

Science and technology has made a major contribution to our nation's strength and to our people's well being, and since the end of World War II the Federal government has played an increasingly significant role in supporting the advance of science and technology. We therefore welcomed the publication early last year of the first comprehensive report on the Federal research and development programs. This report provides a useful overview of the entire Federal effort in support of research and development. It not only includes a breakdown of the research and development efforts in each department and agency, but it also breaks new ground through the functional or "cross-cut" analysis of research and development in such important areas as energy, food, materials, and oceanography.

Yet, as our hearings on the report confirmed, there is room for substantial improvement in this report if it is to serve as an annual review of the nation's science policy. The present report includes our recommendations for strengthening the annual report. With the expected enactment of the Science and Technology Policy bill and the possible shift of responsibility for this report from the Federal Council on Science and Technology to the new Office of Science and Technology, I believe that our review and this report are particularly timely.

In the preparation of this report our Subcommittee had the assistance of Ms. Carol Lee McBee from the Science Policy Research Division of the Congressional Research Service. Ms. McBee attended all sessions of the hearing and wrote the portion of the report entitled "Summary and Analysis of Hearings."

Sincerely yours,

RAY THORNTON,
Chairman, Subcommittee on Domestic and International Scientific Planning and Analysis.

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SPECIAL OVERSIGHT

Research and development is conducted throughout the Federal Government. Most agencies and departments support research and development to further advances in those fields of science and technology which are related to their mission.

In the House of Representatives these research and development activities are reviewed individually by a number of standing Committees having jurisdiction of the various programs, agencies, and departments. Beginning with the 94th Congress, the rules of the House provide that a continuing review of the entire Federal research and development effort be done. For this purpose the Committee on Science and Technology is charged with the function of Special Oversight in this area. Rule X, paragraph 3 (f) provides that "The Committee on Science and Technology shall have the function of reviewing and studying, on a continuing basis, all laws, programs, and Government activities dealing with or involving non-military research and development." This Special Oversight function is to be performed in addition to the legislative and direct oversight function of the standing committees.

The review and the recommendations included in this report are made pursuant to this special oversight provision of the House rules.

RECOMMENDATIONS

The Special Oversight hearings* covered by this report were held for the purpose of reviewing the "Report on the Federal R & D Program—FY 1976" prepared by the Federal Council on Science and Technology. As part of this review the Subcommittee examined three related questions: 1) The status and trends of the Federal R & D program, 2) ways of improving the annual report so that it will better serve as a review of Federal R & D activities, and 3) other possible and important areas of Special Oversight activity which the Subcommittee might undertake. The specific recommendations in this report are limited to the second of these questions.

The Subcommittee, having reviewed the report "Annual Report on the Federal Research and Development Program, Fiscal Year 1976" issued by the Federal Council on Science and Technology and the testimony received in public hearings on that report makes the following recommendations for the improvement of future annual reports on Federal research and development:

RECOMMENDATION 1

The Federal Research and Development Effort Should Be Reviewed Not Only Through Its Individual Components But Also as a Whole

Science and technology is one of America's chief assets in a rapidly changing world. Yet we have not developed an ability to take a comprehensive overview of the nation's science and technology. We continue to view science and technology as a large number of unrelated projects and programs. The research and development budget is largely an after-the-fact aggregation of individual agency and department activities. We must develop an ability to view the research and development budget in its entirety so that the total national effort can be evaluated.

RECOMMENDATION 2

The Report Should Relate Specific Scientific and Technological Activities Supported by the Federal Government to Particular National Goals

Research and Development is not done in a vacuum. Each research or development project ultimately is pursued only because it is expected to contribute to the achievement of a societal goal. The societal goals to which the research and

*U.S. House of Representatives, Committee on Science and Technology, Ninety-Fourth Congress, No. 14, Subcommittee on Domestic and International Scientific Planning and Analysis, Special Oversight Hearing on *Annual Report on Federal Research and Development Program Fiscal Year 1976*, June-July 1975.

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development activities of the Federal government are directed should be made explicit in the report. In order to do this, new and better ways of relating science and technology to the national welfare should be developed and incorporated into the report.

RECOMMENDATION 3

THE DESCRIPTION OF CURRENT RESEARCH AND DEVELOPMENT ACTIVITIES AND THE RESOURCES DEVOTED TO THEM SHOULD BE MATCHED IN THE REPORT WITH AN ANALYSIS OF THE EXPECTED RESULTS AND THEIR USE

Our understanding of the impact of research and development activities is limited by the strong focus on measurement in terms of direct dollar expenditures and specific ongoing departmental and agency programs. Efforts should be made to develop a broader perspective and a better understanding of how the products of scientific and technical efforts can yield results which contribute to the solution of specific problems.

RECOMMENDATION 4

THE REPORT SHOULD INCLUDE AN INDICATION OF PROGRESS BEING MADE TOWARD PARTICULAR GOALS

The report, in some parts, seems to confuse functions with goals. It should focus not only on the research and development process, important as it is, but also on the advances being made and their relationship to the accomplishment of each goal. The end user, or potential end user, should be identified, and the implications of success or failure of research and development activities should be made more explicit in the report.

RECOMMENDATION 5

THE REPORT SHOULD INCLUDE AN ESTIMATE OF THE FEASIBILITY OF ACCOMPLISHING EACH MAJOR RESEARCH AND DEVELOPMENT PROJECT WITHIN THE TIME AND RESOURCES AVAILABLE

The usefulness and therefore the priority given to most research and development projects is strongly influenced by the timely availability of the results and the total resource requirements needed to obtain those results. To permit an evaluation of changing priorities the report should, on an annual basis, provide estimates of the completion date and the cost, manpower and other resource requirements needed to complete each major research and development project.

RECOMMENDATION 6

Measurers of Research and Development Productivity Should be Developed and Incorporated into the Report

While measures of research and development productivity may not be meaningful when applied annually, for periods longer than a few budget cycles it should be possible to measure the benefits obtained from research and development investment so that the societal return can be indicated.

RECOMMENDATION 7

A Distinction Between Directed and Undirected Basic Research Should be Made and the Priority Given Both Kinds of Basic Research Activities Should be Made Explicit in the Report

The generation of basic knowledge is itself a national objective. However, little distinction is made in the report between directed basic research, aimed at achieving a fundamental understanding in the expectation that it may contribute to the solution to a particular problem or set of problems, and undirected research aimed at the generation of new scientific knowledge for its own sake. This distinction should be made in the report and the priorities given the research activities within each category should be set forth.

RECOMMENDATION 8

The Report Should Include a Projection of Estimated National Opportunities and Needs and an Estimate of Prospective Federal Expenditures for Science and Technology

It is now possible to take a step beyond the tactical, year-by-year, crisis oriented approach that has characterized Federal research and developments expenditures in the past. The report should include an annual statement of longer-term proposed research and development expenditures, their purpose, impact, as well as their relationship to policy objectives.

RECOMMENDATION 9

Privately Funded Research and Development Should be Covered in the Report to Permit an Evaluation of its Role in the National Research and Development Effort

In order to place the Federal research and development effort in perspective the report should include a discussion of industrial and other privately funded research and development together with the contribution it makes to national scientific and technological development. National science policy is not

just Federal science policy. Many important components of the national scientific and technological enterprise are not reflected in the programs funded by the Federal government. The inclusion of privately funded research and development should be in sufficient detail to provide a complete picture of goals, trends, and current activities of the country.

RECOMMENDATION 10

The Effects on the Nation's Science and Technology Activities Arising From Regulatory and Other Indirect Influences Should be Assessed and Included in the Report

The indirect effects of regulatory, monetary, patent and other policies on the nation's science and technology enterprise are important. They may at times outweigh the direct effects of research and development expenditures. Although these causes and effects are more difficult to identify and measure they should be analyzed and discussed in the report.

SUMMARY AND ANALYSIS OF HEARING*

Summary

These Special Oversight hearings sought to gain an overview of the general status of the national R&D effort and its implications through a review of the "Report on the Federal R&D Program—FY 1976."

The subcommittee focused on the report of the Federal Council for Science and Technology (FCST) dealing with the Federal research and development program for fiscal year 1976 as a means to gain an overview of existing Federal efforts. Since this report attempted to consolidate available information and present a comprehensive picture of the current programs in this area, the subcommittee asked witnesses to comment on the contents of that report.

The subcommittee heard from the witnesses that there is a great deal of concern for the health of our national R&D effort. Representatives from industry, universities, and various government agencies/organizations expressed a variety of generally negative views about the status and trends of national direction in R&D. Significant factors affecting the posture of R&D, as expressed by those testifying, included:

A decline in the constant dollar support for R&D and thus possible limitations on future programs; the subsequent erosion of the U.S. world technological lead which could have important economic ramifications; an apparent decline in the international prestige and reputation of the U.S. concerning future research and development areas; the increasing pressure nationally to apply existing governmental R&D expertise to solve civil sector problems; the imposition of conflicting or restrictive Federal policies (e.g., regulations, patent policies, procurement procedures) which could hinder the freedom of private R&D efforts; difficulties in effecting successful transfer of technology developed in a research program to those who can and should apply the knowledge and hence the perpetuation of a wasteful time lag in usage; and, the indications of a trend toward Federal monopolization of the basic research efforts in the U.S. for a variety of reasons, a trend which could inhibit full creativity or innovativeness in the future.

Although some witnesses attempted to soften this generally gloomy outlook for the national R&D picture, most witnesses did agree that there were major problems to be considered. The role of Federally supported R&D programs in the overall national effort was viewed as certainly a significant, if not the most influential, factor affecting the status of R&D.

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*This Summary and Analysis was prepared by Dr. Carol Lee McBee, Science Policy Analyst, Science Policy Research Division, Congressional Research Service, The Library of Congress.

Most of the witnesses rated the report favorably but qualified their positive comments with numerous suggestions for improvements. Those testifying seemed to agree that the task of regularly compiling such a document, which concerns a massive, diverse and generally uncoordinated set of R&D programs, would require a great deal of determination, perseverance and skill. Some indicated that first efforts of this sort were not always satisfactory, or up to the standards that could normally be expected after the benefit of many years' repetition of the task.

Many of the witnesses had suggestions as to how the format or style of the report could be improved for greater clarity or readability. Of more significance, however, was the general feeling that the selection and subsequent treatment of contents for the report did not provide comprehensive coverage of the Federal R&D programs. Some suggested, for example, that indications should have been given as to how various agency R&D efforts related, at the very least, to their agency mission and preferably to national goals. Others felt that the report should have outlined and assessed the individual agency's expertise and capabilities for reaching their stated R&D goals. In addition, the use of indicators other than direct expenditure accounting as a measure of R&D efforts was advocated. Such indicators could include enumeration of agency efforts in program evaluation, forecasting, demonstration programs, and so forth. In short, the witnesses felt that the first FCST report, while representing a good start on a seemingly monumental task, lacked somewhat in creativity and thoroughness. They thought that subsequent reports would prove far more effective and useful if content and format changes were instituted.

Finally, the subcommittee asked witnesses to suggest oversight priorities as a guide to future subcommittee efforts. There was no dirth of ideas in this area, and witnesses did not hesitate to present their wide-ranging opinions, since all seemed to agree that a critical overview of Federal R&D programs is long overdue. However, the witnesses did not express any consensus of opinion on just what role the subcommittee could play in its new oversight function. Views on possible future directions for the subcommittee ranged from potentially complex tasks, such as the formulation of a national science policy, to the presentation of numerous projects of a much more manageable nature. Most of the latter consisted of the initiation of reviews or analyses on a variety of topics and included, for instance: an examination of the interaction between Federal R&D activities and those of the private sector; classification of all Federal R&D to determine whether each effort contributes to agency mission or national goals; and, identification of possible duplication in existing Federal programs.

The witnesses seemed to agree that continuing and future Special Oversight of Federal R&D programs would be highly desirable, and could perhaps provide the means for consolidating future efforts to avoid duplication, misdirection, and overreaction, provide for more complete evaluation, and maximize the use of limited funds.

Background and Scope of Hearings

These hearings, held June 3, 4, 5 and 10, 1975 before the Subcommittee on Domestic and International Scientific Planning and Analysis

(DISPA), were the first carried out under the new "Special Oversight" function of the Committee on Science and Technology.[1]

As noted in Chairman Thornton's opening remarks, the subcommittee, in carrying out the Special Oversight work assigned to it, recognizes that much of the responsibility in this effort is shared with other committees and subcommittees of the House, especially those with legislative jurisdictions for the many individual parts of the total R&D program. The subcommittee views the national research and development effort as a delicate and diverse enterprise, involving thousands of talented scientists, engineers and administrators. Although he stated that "there is unquestionably a need to exercise improved congressional oversight in this entire field," the Chairman felt that sensitivity should be the watchword in these proceedings, so that improvement, and not disruption, would be the end result.

Chairman Thornton felt that a useful contribution could be made "by carefully reviewing the degree of planning and analysis which is brought to bear on the Federal R&D program as a whole" (p. 2).[2] Therefore, the subcommittee for its first hearings focused on the "Report on the Federal R&D Program, fiscal year 1976" [3] compiled by the Federal Council for Science and Technology with the assistance of the Science and Technology Policy Office of the National Science Foundation. This report provided the subcommittee with a basis for an examination of current Federal R&D efforts and provided the background for discussions with the witnesses of current and projected trends in the scientific arena and the role that could best be filled by the subcommittee in light of these developments and anticipated national needs, and its responsibility for Special Oversight.

Specifically, the witnesses were asked to emphasize three aspects of the Federal R&D program:

Status and Trends in Federal Research and Development,

Comments on the FCST Report including Suggestions for Improvements, and

Priorities for the Special Oversight of Federal R&D Activities.

The subcommittee felt that testimony on these questions would help develop a clear picture of the highly diverse Federal R&D enterprise which has been evolving over many years.

Seven witnesses were heard in this first round of hearings, including three representatives of industries with major R&D efforts, two National Science Foundation administrators, one university professor and one Executive department scientific administrator.

Analysis of Hearings

In this section the testimony of the witnesses who appeared before the Subcommittee and the submitted, written statements are analyzed and summarized according to the three major topics under examination:

Status and Trends in the Federal R & D Program;

Comments and Suggestions on the FCST Report on the Federal R&D Program, FY 1976; and

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[1] A complete witness list appears on p. 31.

[2] All page references in this summary and analysis are to the printed hearing record.

[3] U.S. Federal Council for Science and Technology. Report on the Federal R&D Program, FY 1976. (Washington. For sale by the Supt. of Docs., U.S. Govt. Print. Off.) 1975. Reprinted as Serial K, Committee on Science and Technology, US. House of Representatives, 94th Congress, June 1975.

Suggestions for Special Oversight Priorities for the DISPA Subcommittee

The testimony by all the witnesses on the individual issues has been compiled and/or analyzed as to content and for clarity this portion of the report is organized according to these three categories.

STATUS AND TRENDS IN THE FEDERAL R&D PROGRAM

The decline in R&D funding levels

Almost all the non-industry witnesses addressed the question of funding, i.e. dollar-support for R&D programs, and usually in comparison with past years. Two of the witnesses (Ancker-Johnson, p. 25 and Long, p. 47), while acknowledging a steady increase in Federal funding of R&D over the last decade, from less than $15 billion in Fiscal Year 1965 to an estimated $21 billion in Fiscal Year 1976, noted that in terms of constant-dollar support this actually represented a 30 percent *decrease* in R&D funding. This lowering of actual support for R&D was by no means limited to the Federal efforts, since this phenomenon has also occurred in the private sector (Ancker-Johnson, p. 25). Such decreases in constant-dollar support indicated an end to the "growth machine" for science in the U.S., signaling the demise of the so-called "Golden Era". (Stever, p. 126).

The specifics of the funding decline were described by Dr. Long who, nevertheless, thought our R&D picture was not so gloomy when compared to other nations' R&D efforts.

> In the United States, R&D expenditures increased rapidly from a fraction of 1 percent in the mid-1940's to more than 3 percent [of the] gross national product by the mid-1960's. Today, at about 2.3 percent of a GNP exceeding $1 trillion, this outlay remains large in relative terms and larger in absolute terms than anywhere else in the industrialized world (pp. 46, 47).

The level of funding was mentioned as an indicator of the current "health" of Federal R&D programs, While Dr. Long expressed his view that the level of effort in the U.S. was large relative to other industrialized nations, others felt that decreased funding, in combination with other factors, could lead to slippage of the U.S. position in the world technological and economic hierarchy.

Erosion of the U.S. technology lead

Dr. Ancker-Johnson testified that decreasing support for R&D in the United States may eventually lead to erosion of our technological lead abroad.

> It is obvious that if our research and development ceases to produce innovation which in turn produces new products and new processes, then the problem of a decrease in our positive balance of trade in the high technology industries will be worse and we will have fewer and fewer products or processes which will be purchased from abroad (p. 25).

Dr. Stever elaborated on this issue, stating that the competitive position of our high technology industry in world trade had suffered a recent decline in some sectors, and that our dominance had even disappeared in certain other areas. He attributed this situation at least partially to—

> . . . the higher level of innovative effort abroad, foreign government financial support for the development of products and of export markets for them, and the heavy concentration of U.S. Federal R&D expenditures in space and defense (p. 119).

The current decline, relative to other nations, in the growth rate of labor and capital productivity for U.S. service and manufacturing enterprises was, in Dr. Stever's view (p. 121), at least partially a result of our decrease in R&D programs and is a threat to our international competitive position. This view was in agreement with the conclusion of Dr. Ancker-Johnson that a decline in Federal support for R&D would lead to decreased productivity and, hence, to an erosion of the international market position for the United States (see quote above).

The possibility that the reputation of the United States in the scientific/technological areas had suffered recently on the international front was explored by Dr.'s Long and Logsden (pp. 64, 65). The changing perceptions of other countries, based on their own technological successes, were posed as one reason for this disillusionment. This, accompanied by the discovery that the U.S. is fallible in some areas, and the observation that our efforts often appear to be fragmented and uncoordinated, accounts for most of the decline in reputation.

In reference to the fragmentation issue, the question was raised whether the United States should pursue a course of increased central planning in its R&D efforts since many highly successful areas of technology have developed without such guides. In response, Dr. Long (p. 65) summarized a possible approach to future national R&D efforts which might improve our productivity and reputation simultaneously. This approach would "point to a middle way between more central planning and continued pluralized effort in which each center of activity pursues its own objectives" (p. 68).

In contrast to some of the positions presented above, at least two of the witnesses gave the scientific and technological communities in the United States a clean bill of health. Dr. Sarett doubted whether our position or capabilities in basic academic science had deteriorated at all. He thought we still possessed the capability to "lead the world". (Sarett, p. 94). Dr. Drew recognized that the leveling-off of growth rate for the scientific community in the late sixties had indeed catalyzed some "serious dislocations" in the system, the aerospace industry providing the most vivid example of this effect. It was his belief, however, that some of the concerns voiced within the academic science community about the health and strength of the scientific enterprise were "overstated" and that worldwide comparison of U.S. technology in essentially every field today placed us in the forefront. (Drew, p. 6).

The developing countries influence our world leadership in technology-based areas in two ways, and both were mentioned by Dr. Stever. The first effect takes the form of—

> . . . shifting international patterns of industrialization exemplified by the plans of the OPEC countries to acquire the technology that will permit them to develop vertically integrated industrial economies based on exploitation of their petroleum resources . . . (p. 121).

The second influential factor revolves around—

> . . . the attack on prevailing international protocols and industrial practices led by the developing countries and directed toward major revisions of the traditional patterns of foreign investment and technology licensing by U.S. firms. Unless mutually acceptable accommodations can be found, these pressures may ultimately lead to an effective elimination of our world leadership in many technology-based areas (p. 121).

It might be noted that although another of the witnesses, Dr. Healey (p. 76), thought that R&D productivity had been seriously affected in recent years, he attributed this trend to inflation in the price of raw materials and energy, shortages of material and energy resources, and escalation of efforts to deal with Government regulations. He did not mention the decline in dollar-support for R&D programs as a factor, nor did his testimony address the question of whether, in his opinion, such an R&D productivity decline would have an effect on the U.S. technological position.

Priorities in the allocation of R&D dollars

Although several of the witnesses recognized that the support level for R&D activities in this country has certainly declined in constant-dollar terms, they disagreed as to whether this has contributed to a slip in technology-dominance internationally. However, the witnesses did agree that a shift in allocation of the dollars available has occurred, with the percentage of Federal support for civil sector R&D increasing substantially. (Drew, p. 7; Long, p. 47 and 57; Stever, p. 123; Ancker-Johnson, p. 28). The basic Federal policy in recent years has been to aid in the solution of a wide range of domestic, civil problems such as urban transportation, food production, and crime control and prevention. Dr. Stever emphasized the importance of R&D in the "soft sciences", adding that their pursuit was difficult since "we don't have the long-term traditions, and it's harder to meet the subject scientifically" (p. 116). The fact that civil R&D problems might in fact prove "more challenging than putting a man on the moon" was noted by Dr. Drew, (p. 7) who also suggested that old methods for R&D might prove ineffective when applied to the complex societal interactions involved in civil problems:

> This added complexity of many of the civil sector problems calls for new management approaches and a better mix between Government and private sector support and involvement and better understanding of the social aspects as well as the physical science and engineering aspects of the problem . . . (p. 7.)

The increasing importance of civil R&D problems would seem to account for the switch in emphasis recently from military dominance of the Federal R&D budget to non-military efforts. There was some disagreement on the extent of this shift, however. One witness said that the civilian share of Federal R&D dollars now slightly exceeds the military share (Ancker-Johnson, p. 28), while another stated that "defense and space R&D still take the lion's share of expenditures" and that in the current budget "the defense share is again increasing" (Long, p. 57).

One result of the increasing Federal commitment to civil R&D has been more public awareness of the amount of support that such efforts require. As a result the general public "increasingly questions the rationale for that commitment" (Long, p. 57). Questions which might naturally arise would concern the necessity for certain research ventures; whether overlap exists among the diverse Federal agencies conducting research; doubt as to what level of expenditure is justified; and fear about environmental, health and/or occupational dangers which result from a particular R&D effort. The public's concern about the dangers has led, more recently, to the establishment of a number of Federal regulatory policies which can affect R&D programs.

Federal policies as disincentives to industrial R&D

Some of the witnesses expressed the opinion that Federal regulatory requirements loom as the single largest disincentive to industrial R&D in the nation. Among the Federal policies mentioned as possibly detrimental to private sector R&D efforts were: inconsistent regulations (Throdahl, p. 98), influence of Government regulations on subject matter for R&D (Fusfeld, p. 74; Stever, p. 118; Healey, p. 76), patent policies, (Fusfeld, p. 74; Sarett, p. 92; Ancker-Johnson, p. 33), tax structure (Fusfeld, p. 74; Ancker-Johnson, p. 26), and Government procurement procedures (Ancker-Johnson, p. 26, p. 32). Two other topics mentioned in this light were not necessarily singular to, or the total responsibility of, the Government: inflation (Ancker-Johnson, p. 26; Healey, p. 76) and availability of venture capital, (Ancker-Johnson, p. 26; Throdahl, p. 109; Stever, p. 119). Rather than speak in terms of "disincentives". Dr. Stever chose to discuss those Federal policies which could be used as "incentives" to industrial R&D. Among these were dollar-investment, regulations, and education (p. 132). Individual views on the above topics follow.

Inconsistent Regulations

Dr. Throdahl concentrated on this topic, suggesting that the syndrome of inconsistency was characterized by two symptoms: fragmentation and erraticism. He felt that not much could be done about the fragmented nature of Government regulatory efforts since different treatment for different situations would be justified (p. 98). On the second symptom, however, he stated that—

> . . . agencies exhibit erratic responses to findings which seem to disclose the existence of a threat to health, and sometimes the ostensibly offending product is immediately proscribed; and sometimes a more rational course of careful examination of the threat and its consequences is followed.
>
> . . . the most erratic agency responses usually occur, by our bias, as a result of the premature release of preliminary data, engineered by some special interest group in order to obtain a public response to force agency action . . .
>
> If we could expect the agencies consistently to take extreme positions with regard to health matters, we would do what seems necessary to prepare for this kind of action. But since they don't do this, the resources that are spent preparing for this eventuality are wasted . . .
>
> It's the inconsistency that hurts, and the inconsistency wastes resources because we must prepare in advance for what we think would be the "worst case," instead of planning to follow a more measured course of response to attack the problem (p. 98).

To remedy the situation, Dr. Throdahl recommended that "strong sanctions be placed on Federal regulatory agencies to act in the spirit of consistency" (p. 98).

Influence of Regulations on the Character of Industrial R&D

This subject was covered most thoroughly by Dr. Fusfeld who observed that while the objectives of those regulatory agencies concerned with environment, safety, consumer protection and so on, were worthy they "also result in shifts within the industrial research structure, and thus raise questions as to whether we are still free to allocate our R & D resources for the most effective contributions to our economy" (p. 74). He estimated that major corporations were currently devoting the following percentages of their R&D efforts to R&D work which is done in response to Government regulations: textiles, 30 to 40 percent; mining, 30 to 40 percent; and automobiles, up to 50 percent.

Our economy has been strengthened by the ability of industrial research to allocate its resources in accord with the criteria of good technology and good economies. The desire to meet national objectives exemplified by the regulatory agencies may result in an unintended and undesirable decrease in the industrial research needed for other urgent national objectives (p. 75).

Dr. Fusfeld recommended that a review of this regulatory-induced subject matter selection for industrial R&D might be in order to determine its possible effect on national science policy.

Dr. Stever also addressed this issue:

. . . the private sectors spend a large percentage of their own dollars, just responding, not directly to doing Government R & D, but to this Government regulation. I'm not against Government regulation, but I think we have to be very careful of the side effects.

Somebody once mentioned that since we now require agencies and industry, and everybody else to provide environmental impact statements on the new applications of technology, perhaps we should provide impact statements on the total R & D effect of a new regulation, or law, or rule. Let's be responsible all around (p. 118).

Patent Policies

Dr. Sarett addressed the problem of patent lifetime, especially its current shortness with respect to the required development time for major new drugs.

In 1962 the development time for a new drug, from the time a new drug candidate was selected until the time it came to the marketplace, was about 2 years. It now runs, in all of its development phases including regulatory review and approval, up to about 7 or 8 years, or even longer up to 12 years, in fact, at the extreme end.

The legal lifetime of a patent is 17 years. During the 1950's and into the 1960's—a period in which the industry, I think, was very productive with significant new drugs—the effective patent lifetime of a new and significant innovation was 13 to 15 years. Today, after the patent is issued, the development time has increased and has eaten into that. Thus, if you take the extreme end of the spectrum—where development occurs over a period of 12 years, and the patent is issued at the beginning of the development period—there might be only as little as 5 years of the patent life left. That 5 years of protective sales of that drug is all that is left for the innovative company that developed the drug to recover its investment, of course, not only for developing that drug, but for all the drugs which failed, and all the other costs which go into research. Thus, there has been a major impact in that sense, and it could be discouraging if extended further. It could have the effect of a disincentive toward discovering and developing new drugs (p. 92).

Dr. Ancker-Johnson emphasized that the private sector has a major problem just dealing with the variety of patent policies now in existence. She stated that there are 17 different statutes applying to patents, plus many individual rules of separate agencies adding to the confusion. She noted that the Government Patent Policy Committee is presently attempting to draft legislation on this issue since—

The view of the executive branch is that it is desirable to have one uniform policy covering patents for the entire Government, given enough flexibility so that such policy can accommodate to the different missions of the various departments (p. 36).

Tax Structure

Although this was mentioned as a "disincentive" to industrial R&D efforts, no elaboration was given in the testimony of witnesses, and it was not specifically pursued by the Subcommittee.

Government Procurement Policies

Dr. Ancker-Johnson mentioned this issue and stated that the possible impact of government procurement policies on new, small enterprises should perhaps be reevaluated.

Availability of Venture Capital

Dr. Stever presented some specific figures on this topic, testifying that a recent study [2] of—

> . . . the equity capital market shows that the funds available for financing small new technological companies—an important source of technological innovation in the past years—declined from about $350 million in 1969 to about $5 million in 1974 (p. 119).

One of the witnesses disagreed, however, stating that "many, many dollars [were] available for investment" in venture efforts, "under the right kind of circumstances" (Throdahl, p. 109).

Transfer of Research Results and Technology

Many of the witnesses expressed concern about the lack of a systematic way to transfer the knowledge resulting from federally supported R&D efforts to those who could best use it. The potential users were identified variously as the private sector, local governments, and other technically developed nations.

Transfer Mechanisms

Dr. Ancker-Johnson testified that "the process of technology transfer from Federal R&D programs into the civilian marketplace has not been very effective" (p. 26). She said that the single operating transfer mechanism is for defense and space R&D efforts where the only customer for the results is the Federal Government itself. The importance of developing a proper, working transfer mechanism for other areas as well, was emphasized in the following statement.

> It is vital that this technology be used not only by the Government, but much more importantly, by the private sector. To assure industrial use, we need to understand better the mechanisms for technology transfer and the impediments to it. We must plan all civilian R&D programs from the beginning with successful transfer as the expected outcome (p. 26).

In further remarks, however, Dr. Ancker-Johnson said that she thought that a good mechanism currently existed for the delivery of scientific and technological data into the private sector and throughout Government in the form of the National Technical Information Service of the Department of Commerce which collects such data for dissemination (p. 26, 27).

Although Dr. Drew mentioned that there are "important Federal efforts underway to improve the technology transfer from Federal and industrial sources to the local level," he did not elaborate as to the specifics. He did indicate that the "receivers" in the technology transfer operation rather than the "senders" were in need of some special attention (p. 13).

Private Sector Users

Dr. Ancker-Johnson stated that there often seems to be a great deal of difficulty in putting technical understanding into practice, particularly when the R&D results come from the Federal Government. As an example, she cited telecommunications technology

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[2] Dr. Stever, in a letter to Chairman Thornton dated July 11, 1975, identified the study as "SBIC/Venture Capital" published annually by S. M. Rubel and Company of Chicago. He further noted that the figures shown in his submitted testimony (p. 124) were corrected by his oral testimony.

which is available but relatively unused. She mentioned that televised two-way communication, televised shopping, personalized entertainment or educational programs, tailor-made newspapers, and electronic mail delivery were all possible (pp. 36–37). Dr. Ancker-Johnson felt that the character of the particular technology determined whether or not the knowledge would be utilized and she also brought attention to several recent studies about the transfer of civilian-oriented, federally-funded R&D into the private sector for commercialization (p. 37).

Dr. Throdahl provided an interesting analysis of recent high-powered Federal effort in areas of applied research to solve immediate problems.

> Without fundamental understanding, applied research often resembles the childhood game of pin-the-tail-on-the-donkey. It is inefficient, it's seldom effective and it often produces some grotesque results instead of attaining the goal.
>
> One of the lessons I think we've learned in industry is that the subunit of an organization that will practice the technology that is built up has to be involved at a very early stage in its conceptual development in order to shape it to the needs and the capabilities of that particular subunit, and we don't see the agency funded by the Federal Government as being the ultimate user of the technology in most cases. Therefore, they need an appropriate partner early in the solution of these pragmatic problems. (p. 99.)

Congressman Ambro, a member of the Subcommittee, expressed his concern about a large Federal R&D effort in areas where there is not an existing, viable industry waiting to use the results. He mentioned the Government's spending of "millions of dollars [to develop] efficient, economical solar capabilities" (p. 105). Dr. Throdahl suggested, in response, that "incentives" could be offered to the private sector, perhaps in the form of a consortium between government and industry, to alleviate this type of situation (p. 106).

Local Government Users

Dr. Drew noted the diffusion of decision making responsibility at the State and local level which has created "a growing need for improved utilization of science and technology on the local scene" (p. 13). He discussed this later in his testimony as:

> . . . the new federalism concept which has dispersed to local and State levels the discretionary authority for the expenditure of sizable new funds. The planning which is necessary on the local scene, the ability to tap the scientific and technological capabilities which exist in this Nation, are therefore of increasing importance with the addition of that discretionary authority for expenditure of funds which has taken place at the local level. (p. 19.)

Technology Transfer To and From Other Nations

There seemed to be some ambivalence as to whether technology developed in the United States should be made freely available to other nations. Although Dr. Ancker-Johnson and Dr. Sarett did not think the technology flow to such nations necessarily should be stopped, they did think that the effects of the process should be recognized and that the Federal Government might at least consider an examination of the issue. Dr. Ancker-Johnson examined the subject in terms of economics.

> . . . the transfer of technology developed in the United States to other technically advanced nations has an impact on our own economy. Witness the Japanese/U.S. balance of trade involving Japanese products based largely on U.S.-developed technology. What is the nature and magnitude of this impact and how are its domestic effects distributed? What policies should the U.S. Government follow, and what monitoring devices or controls, if any, should be established? (p. 25).

Dr. Sarett stated that it was probably beneficial to have the free transfer of scientific information throughout the community of nations, with the exception of military or other information pertinent to the national defense. He did offer the opinion that some attempt should be made to "try to reverse the technological flow to be sure that we take advantage of innovations. . . . overseas" (p. 95). When questioned by the Chairman as to possible mechanisms for this process, Dr. Sarett mentioned that scientists themselves read international journals and attend universities or conferences in other countries. Therefore, the network of information exchange at that level was already established and functioning. He did suggest that the Navy's use of scientific attaches in other countries and the outposts established world-wide by multinational companies would be other mechanisms to consider.

Is there a Federal monopoly on basic research?

The possibility of an increasing federal monopoly on basic research was another major issue raised by the witnesses, and seemed to result from one of the issues discussed specifically regulatory policies. Since the private sector devotes a considerable portion of its R&D resources to regulatory response, it was argued that the burden for basic research support has now fallen to the Government itself. Some of the witnesses expressed concern as to whether this would result in the best utilization of talent to pursue innovative R&D efforts. Dr. Stever observed:

> . . . that the Federal Government almost has a monopoly in the support of basic research now. The performance of basic research is largely in the universities, some in industry. But we, the Federal Government, support the basic research in the universities and in industry, and the rest of the S&T spectrum: the applied research, the technology and the development of products, all the way from great big systems like those for big aircraft to very small products. Support of the latter, of course, is shared by the Federal and private sectors.
>
> . . . the Federal role is very powerful, and growing more powerful, and I think it would be a very good thing to study that changing role in depth (p. 127).

In discussing trends in the R&D programs for the nation, Dr. Drew testified that it was basic to U.S. policy that "each mission agency conduct a basic research enterprise and support a basic research enterprise which is relevant to their mission needs but which is oriented towards the production of new fundamental understandings in the field" (p. 8). He did not share the view of Dr. Stever, however, that such efforts were tending to become monopolistic.

Whether or not the Federal support of R&D was becoming too dominant did not strongly concern Dr. Throdahl, one of the industry representatives, who recommended that "Federal support of basic research should be strengthened and redirected, and it should not be diluted . . ." (p. 99). He, in fact, cited some governmental actions which in his view, have *not* been supportive of further basic research on the part of the Government:

> During the past 5 or so years, agencies which have traditionally supported basic research, . . . have increasingly been forced to divert from such support to emphasis on near-term application, an activity for which they are usually ill prepared. I cite the so-called Mansfield amendment, which has hamstrung support by Defense of the basic research from which new approaches to national security would be derived. The RANN program, for another, has diverted major National Science Foundation funds and efforts to applied programs for which the National Science Foundation, in our judgment, has little talent, and to which the National Science Foundation structure and procedures are inappropriate, and results have

been miniscule. A sound national program of basic research is essential to provide the firm basis for new ideas and new technology that will be needed for breakthroughs in all areas, such as defense, space, health, environment, energy, the economy, and, of course, indirectly, in the constructive solution of some key social issues (p. 99).

A divergent view of the Federal impact on allocations of R&D funds by the private sector was presented by Dr. Fusfeld in his prepared testimony. He stated that the "generation of knowledge by Federal R&D expenditures increases the reservoir available to industrial research. The large Federal expenditures on basic research in the past 20 years [have] probably been one factor in the decreased emphasis on basic research by industry" (p. 75). Thus, Dr. Fusfeld seemed to indicate that increasing emphasis on basic research in Federal efforts prompted decreased efforts in that area by the private sector. This is certainly in contrast with the other witness's testimony that Federal regulatory policies forced the private sector away from the pursuit of basic research.

Capsule view of status and trends

The non-industry witnesses tended to look at the trends in Federal R&D in terms of funding levels. Two of these witnesses noted specifically that the level of R&D funding has decreased by 30 percent in constant dollars, even though budgets have increased in actual, current dollars. The effects of such declining support for R&D were viewed by some witnesses as detrimental, significantly with respect to the status of the U.S. technology lead in the world. Some of the witnesses stated that lowered support for R&D could lead to decreased total national productivity. Another of the witnesses attributed the current observed decrease in the R&D productivity component, considered separately, to other factors such as inflation, materials shortages, and Government regulatory policies. In contrast, the two NSF representatives testified that the U.S. capabilities in scientific and technological areas had not deteriorated. Whether the international reputation of the United States had suffered recently was discussed in some detail and one of the witnesses suggested that more central planning in our R&D efforts might improve this situation. Additionally, the influence of developing countries on our world leadership position in technology was emphasized.

A second funding issue covered in the discussion of R&D trends concerned the allocation of R&D dollars. Most of the witnesses agreed that Federal support for R&D to solve civil sector problems had increased, with a corresponding decrease in the percentage of Federal R&D devoted to the military. There was some disagreement on the latter point, however. One witness noted that public awareness of Federal R&D activities had increased since those activities often involve, or affect, matters of public concern.

A major portion of the industry representatives' testimony on this topic involved Federal policies which have served as "disincentives" to R&D efforts in the industrial community. Among the policies mentioned were: regulations, tax structure, Government procurement procedures, patent policies, and inflation. These comments were not confined to the industrial community representatives, since other witnesses often mentioned the possible major effects the Government can have on the private sector, at least in some of the areas.

The transfer of R&D technology developed in Government-sponsored programs was also covered in some detail. It was felt that with few exceptions, the mechanisms for such transfer are nonexistent or are often inefficient. Almost all of the witnesses expressed some opinion on this issue, although there was a spread of opinion as to *who* the major users of R&D technology would, or should, be. Some identified the most likely users as the private sector, specifically the industrial community, who could translate such knowledge into useful products and services. Others noted that local governments were in need of such information in line with their newly acquired responsibilities consistent with the policy of 'new federalism'. Still others testified that the most consistent users of our R&D technology have been other technically advanced nations, and that the Government should examine whether such unfettered transfer was healthy.

The status of Federal support for basic research efforts prompted a variety of comments on the part of the witnesses. One person testified that the Federal Government was monopolizing basic research and that a study of the issue in depth would be in order. Other witnesses thought that support for basic research should certainly not be diluted and should, in fact, be increased. One of the industry representatives thought that increasing Federal efforts in basic research was allowing industry to use its funding allocations for other types of research, while benefiting from the Federal program results.

COMMENTS ON THE FCST REPORT AND SUGGESTIONS FOR IMPROVEMENT

The report on the Federal Research and Development Program for Fiscal Year 1976 was compiled by members of the Federal Council for Science and Technology (FCST) with assistance from the National Science Foundation's Science and Technology Policy Office. The budget figures used in the document were taken from the Budget of the United States Government as developed by the Office of Management and Budget and from figures supplied by the individual agencies.

The report format provides for an initial overview of the trends in Federal support for R&D and an analysis of the role of R&D in a technologically based society. In this overview section a quantitative picture of the large agencies' obligations for R&D over the last decade is presented. The second part of the report summarizes the R&D programs for individual agencies. Included are: the Departments of Agriculture; Commerce; Defense; Health, Education, and Welfare; Housing and Urban Development; Interior; Justice; State; and Transportation; and the Energy Research and Development Administration; Environmental Protection Agency; Federal Energy Administration; National Aeronautics and Space Administration; National Science Foundation; Nuclear Regulatory Commission; Smithsonian Institution; and Veterans Administration. A common format is not used in this section, presumably because the individual agencies provided their own information. Some agencies present their R&D activities by topic area concentrations while others break out their activities according to the activities of the bureaus or offices under the agency. In some cases, budgetary figures for the fiscal years 1974, 1975 and 1976 are given, in others only the expected expenditures for fiscal year 1976 are indicated.

The final substantive section of the report deals with the significant R&D activities which occurred in selected "functional areas." Nine topics were selected for these cross-cutting analyses: Basic Science, Climate, Energy, Environment, Food, Health/BioMedical, Materials, Oceans, and Social R&D. The criteria for selection of these particular topics was not mentioned. A note in the Introductory Notice of the report says that the ". . . functional analyses are provided to give a better sense of real scale and character of Federal effort in selected areas of national concern."

The Federal Council for Science and Technology

Dr. Granger, on the first day of the hearings, provided a brief overview of the FCST, noting that the Council, which has functioned since 1959, ranks as one of the oldest surviving elements of the science advisory apparatus (p. 8). He described the membership as including the heads of the various technical agencies and the cabinet-level departmental appointees responsible for science and technology. Dr. Granger summarized the range of activities of the FCST as follows:

> The Council concerns itself with two basic kinds of activity. One is to develop common administrative approaches to problems cutting across the R&D activities of all the Federal agencies, such things as patent policies, some aspects of procurement policy, et cetera.
>
> The other, which is quite different, is to provide a shelter under which the technical agencies or technical community of the Government and the Science Adviser can organize, monitor, and plan new and substantive programs of such breadth and scope that they cut across the interests of many of the agencies.
>
> For example, there is the Committee on Atmospheric Sciences, which is one of the earlier ones and which includes many of the interests of NOAA, DOD, NSF, and others. There is a Committee on Marine Sciences and Engineering and one to coordinate the planning for the construction of major new facilities for astronomy.
>
> We have recently formed a Committee on Materials. We have a task group on Inadvertent Modification of the Stratosphere—IMOS—a problem of great interest currently and a Committee on Water Resources Research (p. 9).

General evaluation of the FCST report

Most of the witnesses, in their general evaluations of this first report, expressed favorable opinions about the efforts of the FCST. However, there were a number of suggestions for improvements, and some were more critical than others. The following examples summarize the basic tenor of the comments: Dr. Ancker-Johnson, ". . . it represents a good first effort," (p. 31); Dr. Long, " . . . a useful document . . . If [it] is to be annual, it should issue from an agency equipped with the capacity and the authority to do a first-class job" (p. 48); Dr. Fusfeld, ". . . an excellent start in the process of review and planning of the Federal R&D effort . . . provides a solid starting point for discussion" (p. 73); Dr. Healey, ". . . applaud[s] the FCST for producing an outstanding report. . . . it will certainly serve as a valuable reference volume" (p. 77); Dr. Throdahl, ". . . a perspective of the most important research needs is not clear to the reader of the [report] . . ." (p. 100); Dr. Stever, ". . . I want to go on record to congratulate Dr. Drew of my staff and the team that has worked with him . . . this is one of the new things we did . . ." (p. 116). In addition, most of the witnesses offered suggestions for improvement of the style, format, or content of the report. More detail is provided in the following sections.

Content improvements

A variety of comments were presented about the contents of the FCST report. Some suggestions would lead to a much broader scope for the report. For instance, the suggestion that an attempt on the part of the FCST to relate R&D expenditures of individual agencies to their own missions or to national goals would require a much-expanded analysis. Dr. Ancker-Johnson testified that her major criticism of the report was that it did "not assess the effectiveness of individual agency R&D [programs] in achieving national goals" (p. 32). In the same vein, Dr. Drew commented that greater attention could be given to "the rationale and objectives which have played an important role in decisionmaking within the various specific agency programs, including greater analysis and overall interpretation of the thrust of the program" (p. 11). Dr. Healey also concurred in this suggestion, observing that the value of specific technical objectives in relation to larger national goals should be judged "by the sponsor or potential user of the program results" (p. 79).

Two other suggestions were made concerning the objectives of R&D programs. Dr. Drew thought that future reports should attempt to estimate whether agencies are utilizing their capabilities properly in their R&D programs (p. 10). Dr. Healey recommended that estimates be made of the feasibility of accomplishing stated R&D objectives taking into consideration the availability of time and resources (p. 79).

Dr. Long pointed out that the traditionally itemized categories for R&D expenditure accounting, i.e. salaries, capital investment, cost of experimental materials and equipment, may not be sufficient. He felt that a significant amount of Federal expenditure that could be logically included in such accountings was at present omitted:

> This involves, for example, expenditures of agencies and departments for program evaluation, economic and social forecasting, and design and experimental demonstration of social programs. Whether or not this form of expenditure is considered direct, it seems to us an increasingly important way in which skills and techniques of the scientific community are applied to the achievement of social objectives through government expenditures (p. 52).

He also suggested that indirect support of R&D through policies and practices other than direct funding should be accounted for. He noted that—

> These devices are extremely varied, and include: regulatory and standard-setting practices, procurement operations, tax and lending policies, trade and monetary policies, economic policies, personnel policies, and education policies (p. 52).

Dr. Long summarized his views on this issue: "Different measures, and different ways of conceiving of the relation of science and technology to national well-being, would add considerably to the flexibility and the sophistication of oversight and the coordination of R&D expenditure" (p. 52).

Dr. Throdahl, in his prepared testimony, analyzed eight of the nine functional areas and stressed their importance in future R&D efforts. He did not include "Oceans" in his list of functional areas, but did suggest the inclusion of five other categories: Fire Prevention and Control, Earthquake Forecasting, Transportation, Information Services, and Planning. He further remarked that the current and projected expenditures for social research seemed "excessive for what is being accomplished" (p. 103).

Other suggestions would involve some forecasting at the time of report preparation. For instance, Dr. Healey thought that the report should include some indication of how a developing technology could be used, either by the Government itself, or by the industrial community (p. 77). The Chairman questioned Dr. Drew as to whether efforts should be made to determine the availability of scientific manpower in different fields in order to avoid manpower shortages (p. 10). In response, Dr. Drew acknowledged that such projections were indeed useful and were certainly feasible. He did point out that manpower reports are now issued by the Science Resources Services of the NSF and that future FCST reports might "consider highlighting a few selected aspects as they are relevant to the overall R&D program" (pp. 11–12).

Other types of additional material suggested for future reports centered on the inclusion of the R&D efforts of other groups for comparative purposes. Dr. Fusfeld, for instance, stated that completeness and perspective on a national scale could only be achieved by inclusion of "the diverse and critical industrial research effort" (p. 73). Dr. Drew thought that the objectives and achievements of the Federal Council for Science and Technology itself should be considered in future documents (p. 11). He also suggested that the inclusion of non-Federal R&D investments, perhaps in a historical sense, and international R&D investments could improve the report.

Dr. Long summed up his feelings about the benefits to be had if the FCST report were to be generally improved:

> Several specific advantages would be gained by improving the quality and regularity of annual R&D expenditure data: comprehensive dollar accounting can improve knowledge of the direction and rate of changes in expenditures; reporting in a common format will permit comparisons between agencies, and between programs within agencies; expenditures associated with acknowledged social goals can be carefully tracked; and expenditures might be more effectively mobilized for particular, short-term policy goals.
>
> These advantages are related primarily to the improvement of data for past fiscal years. But we believe it is worth the effort required to collect data at the time budgets are being prepared for the next fiscal year. Only in this way can changes in emphasis or direction be submitted to the scrutiny of Congress and other interested parties (p. 51).

Format/style improvements

Dr. Drew, who was closely involved with the production of the FCST report, was the first to single out its shortcomings. He mentioned specifically that improvements in the accounting system would be needed, so that the support supplied for a specific functional area within the Federal R&D program could be extracted and double-counting eliminated (p. 11). He also mentioned that there might be more expansion and interpretation of the program areas presented. The rest of his comments pertained to the contents of the report as summarized in the preceding section.

Dr. Long provided the most comprehensive and critical comments on the format and style of the report. He suggested that ". . . a more precise and rigorous attempt at comprehensiveness would probably result in the addition of some agencies" (p. 48). He pointed out that it was unclear whether or not any of the regulatory agencies had been included at all. Further, he questioned the reliability of the data presented:

> Since the collection of data internal to each department and agency was presumably left to that department or agency to organize, there is no assurance

that all relevant programs and funds of component agencies were included. Given some assurance as to the uniformity of criteria, we would be more confident of the comparability of the numbers reported by different agencies (p. 48).

Dr. Long also said that the use of a common format for the presentation of departmental and agency R&D expenditures, as well as a common level of detail, would be desirable in future reports. As an example of the confusion in the report, he pointed out that the figures for DOT were grouped by objectives, those for HUD were grouped by program, and the expenditures for HEW were organized categorically within the department's three main subdivisions. He noted also that for those agencies with expenditures of less than $100 million annually, no comprehensive R&D expenditure data were given for the whole agency, although the State Department gave expenditures for its component agencies. The sparse attention given to the budgetary details of the NSF programs was surprising to Dr. Long in view of the NSF's responsibility for R&D data and its central role in the Federal effort (p. 49).

In his analysis of the functional area presentations in the report, Dr. Long noted that the nine selected topics conflict with the 12 functional areas which have been used by the NSF for the past three years in its analysis of Federal R&D expenditures. He also pointed out that budgetary data is provided for some functional areas and not for others. Singling out the sections on Health/Biomedical and Basic Science, he stated that "neither functional analysis provides better data or different arrays than what is normally available from agency budgets" (p. 50). Dr. Long also observed that—

> . . . very different considerations may be involved when analyzing a functional area dominated by a lead agency as compared with a functional area that is highly diffused in agency R&D budgets throughout the Government. The usefulness of a functional approach may be much greater precisely in those cases where there is no agency bearing the main responsibility (p. 51).

Dr. Healey recommended that the existing index could be improved with more detail, and that the addition of a "glossary of abbreviations would improve the report's usefulness as a reference" (p. 79). He also suggested the greater use of charts to indicate the qualitative content of agency programs and how they relate to national objectives (p. 79).

Capsule view of the FCST report

The FCST report, consisting of nearly 200 pages, was prepared by the Federal Council for Science and Technology and covers the R&D activities for Fiscal Year 1976. The programs of nine executive departments and eight other agencies with R&D missions are included. The report is composed of two major sections: the first gives details of individual departmental or agency R&D programs, with some budgetary detail, and does not have a common format; the second is divided into nine functional areas, giving the various agencies' contributions to R&D in those fields.

The witnesses generally rated the FCST report favorably, although most included some substantive comments and suggestions for improvement of future reports. The suggestions ranged from those dealing simply with format or style, to those critical of the content of the report.

Comments aimed at content improvements were quite varied. A few of the witnesses suggested that the report should analyze R&D programs in terms of the potential achievement of national goals.

One witness thought that, at the very least, each agency should give an indication of how the R&D activity it supports fits into it's own mission. Another testified that the capabilities of agencies to perform the R&D in their programs should be assessed, along with the feasibility of accomplishing stated objectives. The exclusive use of traditional, direct expenditure accounting was declared insufficient by one witness, who suggested expanding future reports to include assessments of indirect expenditures. Possible items to be included in such indirect funding accounting would be expenditures for program evaluation, forecasting, and demonstration programs. Indirect support of R&D through policies and practices, such as regulations, procurement procedures, tax structure, educational programs or standard-setting, should also be included in future reports according to this same witness. Another witness presented his own suggested list of functional areas, expanding on the list that had been included in the current report. Some suggestions were made that would require forecasting on the part of the FCST in the areas of manpower shortages and the possible uses for developing technologies. The industry representatives who testified felt that the research efforts of the industrial community should be included for comparative purposes. Others suggested the inclusion of international R&D investments, although the difficulty in obtaining these data in a timely manner was noted.

The following format and style improvements were suggested: use of a better accounting system for dollar allocations; more comprehensive reporting; improved data reliability; use of a common format; increased originality in data presentation; expansion of the index; the addition of a glossary; and the inclusion of more charts.

One person stated that a high degree of congressional attention to the report would be the best method to ensure its future improvement.

SUGGESTIONS FOR SPECIAL OVERSIGHT PRIORITIES FOR THE DISPA SUBCOMMITTEE

The witnesses addressed a wide variety of issues in their suggestions for possible priorities for the subcommittee in its new Special Oversight responsibility for Federal R&D. Most of the individual possibilities could be classified as separate 'projects' or 'policies' that could either be advocated or initiated by the subcommittee. These ranged from the undertaking of reviews of certain areas such as patent policy, the legality of government-industry 'consortia', or the overlap in the total Federal R&D effort, to the development of certain capabilities on the part of the subcommittee, for instance the education of its members as to stated goals of the Congress or individual agencies for R&D priorities. A listing of these proposed projects follows, with some elaboration as to the mechanisms for accomplishment of or rationale for these tasks where provided. The concluding section summarizes the preferences on the part of some of the witnesses to have the subcommittee provide the focus for the establishment of a national R&D program which would mesh with national goals, and the establishment of a new approach by the Federal Government to its R&D role in the civil sector.

Suggested policies or projects for DISPA

A number of the witnesses suggested that the DISPA subcommittee undertake reviews or analyses of certain issues or areas. These took the form of either internal reviews of mechanisms in the existing Federal R&D system or external reviews of other R&D systems.

External Reviews

Dr. Drew stated that the United States could profit from the review of other nations' approaches to R&D planning and decisionmaking. He elaborated on the systems represented by the Western European countries, particularly those belonging to the OECD (p. 20), and on the various systems of the Eastern Bloc countries, with their highly structured planning and management approach to government resource allocation. Dr. Drew summed up his views:

> Some of them are of potential applicability in the United States, at least in some slightly modified form to respond to our governmental system. We should, as a nation, be prepared to learn from others and to take from them the best of their systems and be willing to adopt approaches which they may have tried and may have found successful and which would work in our system.
>
> What I am suggesting here is that I think we have clearly not arrived at the ultimate system for the allocation of resources for research and development on the Federal scene and we should be willing and in fact be quite open to the prospect of learning from others (p. 20).

Dr. Healey recommended that "appropriate cognizance" be taken of the industrial and other private sector R&D programs (p. 79), since coordination of programs between the Government and industry in such areas as product safety would prove useful (p. 81). He stated that the "present climate of the Congress particularly discourages . . . the interaction [between industry and Government]" (p. 81). He felt that many cooperative programs have been destroyed due to accusations that such efforts naturally lead to the captivity of an agency by the industry involved (p. 81). Dr. Healey did say that a complete survey of industry was not possible in itself, but that the subcommittee could utilize Government agencies to obtain information about individual industry activities. Dr. Sarett expressed his agreement on this issue and noted that "congressional understanding and acceptance of the essential role of industry research in the Nation's total research and development efforts" was of critical importance (p. 89). He especially pointed out that recognition should be given to "industry's special role in the effective development of products that serve a useful public purpose" (p. 89).

In his suggestions for the subcommittee's priorities, Dr. Long discussed another subject external to Federal R&D funding, the topic of manpower planning. He said that—

> The Federal Government, having become, directly and indirectly, the major employer of highly qualified scientists and engineers, bears a responsibility to project requirements and patterns of skill utilization. Such projections could be requested along with annual expenditure projections, and viewed as a supplement to budget data. In the longer term, manpower planning could add another dimension to the process of tracking, evaluating, and directing the contribution of R&D to social goals (p. 52).

Specifically, Dr. Long recommended that the subcommittee undertake a review of various efforts now underway aimed at better forecasts and policy tools in the manpower area. He felt that the subcommittee could assess the progress of these efforts and determine whether useful results are being obtained (p. 52).

Dr. Stever suggested that the subcommittee look into the "different attitudes" of the industrial R&D community, but for the purposes of deciding what actions the Government could take to provide "incentives" for R&D in innovative areas (p. 132).

Internal Review

Dr. Throdahl thought that all Federal R&D expenditures should be assigned priorities according to three policies:

> The Committee on Science and Technology might well insist that each Federal Government department intending to utilize Federal dollars for R&D develop department or agency objectives and goals to achieve such objectives. These objectives and goals would then become the basis for approved Federal R&D funding, either intramural or extramural, along the following policies—there are three of them—which are in selected fields which would be appropriate to the well being of the Nation . . . (p. 97).

The three policies suggested by Dr. Throdahl are: mission R&D, which may be highly uncertain and therefore costly, and which may exceed the resources of the private sector; fundamental R&D that would lead to a knowledge bank, freely available to the private sector; and R&D projects leading to useful by-products, such as highly-trained personnel (p. 97). Although Dr. Throdahl thought that these three policies would be useful to the subcommittee in the matching of funding dollars to Federal agency goals and objectives, he did not suggest the relative importance of the R&D categories.

Dr. Long also thought a review of proposed R&D expenditures should be undertaken under the auspices of the Special Oversight function. He felt that this could be accomplished by instituting—

> . . . the requirement by this committee of annual statements by an appropriate executive branch agency—possibly a White House science advisory structure as is currently being discussed—describing and analyzing proposed R&D expenditures in the new budget. These statements should contain two kinds of material: (1) they should define the ranges of new budget authority and outlays for the Federal R&D effort in such a manner that agency and departmental missions, as well as major functional activities, can be assessed in relation to past and current funding levels; (2) they should reflect the connection between economic, social, and international policy objectives of the Government and proposed expenditures (p. 54).

He stated that such action on the part of the subcommittee would make it possible "to take a step beyond the tactical, year-by-year, crisis-oriented approach that has characterized Federal R&D expenditure in the past. . . . the oversight function can develop into a strategic overview of the interplay of R&D resources with existing and emerging social goals" (p. 54).

Another type of review activity suggested by Dr. Healey concerned the possibly wasteful duplication of R&D efforts in federally-funded projects. He thought that the subcommittee should take steps to "insure" that such is not the case (pp. 77–78).

Dr. Ancker-Johnson listed a number of review efforts that could be undertaken by the subcommittee. Specifically, she felt that (1) the process of technology transfer from Federal R&D programs should be examined in detail (p. 32); (2) the economic and regulatory climate for the creation of small, innovative technical enterprises in the private sector needs analysis (p. 32); (3) the subcommittee could develop data on the effects of inflation, regulatory policies, Government procurement procedures, and scarcity of venture capital on the creation of new technological enterprises and could recommend ways

to encourage the start-up of such enterprises (p. 32); (4) an examination of the legal and institutional constraints to the formation of industry-government or multi-company cooperative R&D programs for the development of high-risk technologies could be undertaken (p. 32); (5) a review of the multi-faceted Federal patent policy was in order (p. 33); and, (6) the subcommittee might address the use of Federal technology policy and programs to enhance the growth of productivity in the United States (p. 33).

Finally, a number of witnesses suggested that the subcommittee should analyze Federal R&D efforts in the light of "national policies and goals." These included Dr. Ancker-Johnson (p. 32), who thought that the subcommittee should "make recommendations as to whether the existing and projected non-military Federal research and development programs are being responsive to the achievement of our national goals"; Dr. Fusfeld (p. 74), who suggested that "exploratory efforts be initiated to . . . provide an improved perspective on how the total scientific and technical efforts of the country contributed to overall national objectives"; and Dr. Healey (p. 77), who recommended that the subcommittee "assess whether the Federal R&D program is properly balanced in distribution and emphasis so as to produce the science and technology required to meet the national goals."

Dr. Healey stated that in order to accomplish this task the subcommittee would have to undertake an educational process to "make sure it is aware of the nonmilitary long- and short-range goals, both national and international, as established by the executive and legislative branches of the Government" (p. 77).

Other Special Oversight Projects

A number of other activities to be done by the subcommittee as part of its Special Oversight function were suggested by the witnesess. Dr. Healey thought the subcommittee should seek the advice of such groups as the National Academy of Sciences and the Industrial Research Institute on a continuing basis. He also thought that reassessments of the feasibility of success of various R&D efforts should be made on an annual basis (p. 78).

Dr. Long recommended that the subcommittee develop its capabilities to serve as a "listening-post for trends in science, technology, and their social and economic implications" (p. 56).

Two of the witnesses suggested that the subcommittee might make recommendations for scientific policy impact studies which assess the consequences or results of policy decisions. Dr. Logsden observed:

> [these] techniques might be applied—perhaps covering 5-year periods—to large-scale R&D activities not normally evaluated in the budgetary authorization or appropriation process. For example, the progress of high-energy physics or ground-based astronomy; the cost and effectiveness of peer review in the health-biomedical—or other—areas; methods of funding and monitoring Federal contract research centers; and interagency mobility of R&D personnel—these suggest the kinds of impact and assessment studies we have in mind. This committee may be the appropriate body to select them, while OTA should perhaps conduct them (p. 53).

Dr. Stever was the other witness to address this issue. He noted that people who have studied the structure of science have suggested that better analytical policy studies that look into the future are needed.

He also indicated that such studies should be part of the "action part of our government, which includes the Congress, in each year's budget" and he hoped "that this committee will always look to that part of its role" (p. 130).

Despite the fact that the military side of R&D expenditure is not included within the committee's oversight mandate. Dr. Long stated that:

> . . . we cannot conceal the conviction that there is on hard and fast line between the military and the non-military parts of the national R&D effort. It would be a mistake not to acknowledge this fact and not to consider its consequences . . . We hope that this committee will seek expert guidance, and will not permit so important a subject to be ignored (p. 55).

Formation of a national science policy

Several of the witnesses testified that until the Nation had an established science policy, the role of the subcommittee in its oversight activities would be difficult to clarify. Dr. Fusfeld, for instance, felt that any report on future Federal R&D activities should provide answers to the following questions:

> 1. Is the division of effort among the various programs good or bad?
> 2. Are we making progress toward particular goals, and how do we measure this?
> 3. Do we have good overall perspective of the relative contributions of Federal and industrial R&D?
> 4. Can we relate the various Federal R&D expenditures to a set of missions or functions that have definable endpoints, time tables, and a realistic estimate of resources required for exploitation—capital, manpower and materials? (p. 73).

He explained further:

> I can state explicitly what these questions imply. We need, and do not yet have, some attempt at a national R&D program plan. We need to spell out as clearly as possible the implications of success in our R&D and provide the mechanisms for its exploitation. We need some sense of priorities (p. 73).

Dr. Sarett also addressed this issue, urging the subcommittee to focus its attention on national science policy, not just the Federal aspects. He noted the interdependence among scientists and scientific institutions, both public and private, and urged "the reinforcement of present instrumentalities and the creation of new ones to facilitate the broader representation of science in the formulation of national science policy" (p. 87). In fact, Dr. Sarett stated that "Congress should concern itself with strengthening the mechanisms and incentives insuring that scientific knowledge is applied toward the achievement of socially useful purposes" (p. 88).

Dr. Stever alluded to the formation of policy in his discussion of the possible impact of the Federal Government on the national R&D picture.

> . . . the ultimate goal of the pursuit of technology, in the private sector as well as Government, is to impact our economic and security interests and the quality of life led by our citizens and, indeed, by the citizens of the whole world . . . this subcommittee [has] a significant role[s] to play in these issues, since each impinges directly upon the health of our national S&T enterprise and the ability of that enterprise to serve our national interests. Specific questions of program directions and priorities for the technical agencies are clearly involved, as is the appropriate reach of the concerns of the science advisory apparatus, whatever form that may ultimately take.
>
> The Subcommittee on Domestic and International Scientific Planning and Analysis most certainly has a central role to play in shaping the Nation's responses to these problems (p. 122).

Dr. Drew analyzed the specifics of the formation of a national policy for science in terms of funding, and explained the advantages:

> In the field of R&D planning the United States has traditionally accepted the concept that the dynamics of the current scene require a highly flexible approach to R&D support and an annual decisionmaking process which could reflect changing current conditions and priorities. In institutions such as universities, however, the ability to respond to annual fluctuations in support for specific program activities is limited by the nature of the institution. For many reasons it would be highly desirable to have a somewhat more predictable future and a certain stability in R&D funding support.
>
> This potential conflict between the desire for better long-range planning and greater predictability in terms of resource availability and the need to retain a dynamic character to our R&D program presents an interesting challenge to the executive branch and the Congress (p. 13).

The formulation of a national policy for R&D might result in some changes in the Federal role in civil sector R&D. Dr. Drew, for one, thought this would be advantageous, stating that "the health of [the] industrial complex may require some rather new approaches to the Federal R&D role in the civil sector. It may also require other changes or incentives which are not direct R&D investments but rather stimuli . . . such as modifications to the tax structure or patent and licensing policies or the ability to perform cooperative industrial R&D" (p. 12).

Dr. Stever predicted that the work of the subcommittee will—

> . . . prove ever more important. It's going to be tough work because it's going to deal with ideas, and concepts, and reasons behind the programs. It's always so much easier to get down to the nuts and bolts of the budgets, or questions such as is that project better than this one. But the fact is, in an endeavor as big and as important as science and technology in our country . . . the Congress . . . the administration, and people in the community of science and technology—just have to address these general issues more, and understand them, and get the reasons behind them (p. 115).

Capsule view of special oversight priorities

The range of suggestions from the witnesses for oversight priorities of the Federal R&D effort covered a broad spectrum, from the establishment of a national science policy to a variety of fairly uncomplicated 'projects', such as the examination of various individual topics. Most witnesses felt that the subcommittee could play an important role in the planning of the increasingly complex national R&D effort, although there was not a great deal of overlap in opinion as to just what that role should be.

Many of the witnesses thought the subcommittee should initiate a number of reviews or analyses as their initial step in the oversight function. These could be classed generally as internal in nature, that is, involving the review of some aspect of the existing Federal R&D program in detail; or external in nature, concerning the review of other, non-government R&D activities to determine their relation to the Federal program. Suggestions for internal analyses were most prevalent. They included: (1) determination of the relation between proposed expenditures and economic, social, and international policy objectives; (2) identification of duplication in R&D programs; (3) examination of the technology transfer mechanisms for R&D results; (4) review of the effects of current Federal policies on the creation of new technological enterprises; (5) examination of the legal and institutional constraints on 'consortia' for the accomplishment of high-risk R&D; (6) review of Federal patent policy; and (7) classification of all

R&D according to whether it contributes to agency mission or national goals. In the same vein, one of the witnesses suggested that all Federal R&D expenditures should be assigned priorities according to three possible R&D policies: mission R&D, fundamental R&D, or R&D yielding useful by-products. In short, the witnesses seemed to be in agreement that the Federal R&D programs were in need of a great deal of oversight.

One of the reviews of an external nature that was suggested involved examination of the interplay between Federal R&D activities and those in the private sector, specifically the industrial community. Some of the witnesses expressed the need for more cooperation between the Government and industry in their research efforts. One of the witnesses thought that proper congressional recognition should be given to industry's role in R&D that can serve a useful public purpose. Another witness stated that an examination of international R&D policies might lead to improvements in the Nation's approaches to research programs. On the subject of manpower planning, one witness suggested that the subcommittee should review and assess the various efforts now underway in that area to determine if useful results are being obtained. The rationale for such a project stemmed from the fact that the Government is the major employer of scientists and engineers at this time.

Some of the other suggestions for subcommittee priorities included the use of existing scientific organizations for advice; the development of 'listening-post' capabilities to detect trends in science; the selection of topics for scientific policy impact studies; and the inclusion of military R&D oversight, at least as it relates to non-military R&D.

Four of the witnesses specifically suggested that the subcommittee or the Congress should formulate a national science policy. Most felt that the assessment of R&D efforts would be difficult in the absence of such a policy. One witness thought that it would be desirable if future R&D activities were more predictable and if there were more stability in R&D funding support. This witness thought that these advantages would naturally result from the formulation of national science policy.

It was repeatedly observed during these hearings that the work of the DISPA subcommittee will be important but difficult since R&D program ideas, reasons, and concepts would have to be dealt with.

APPENDIX

List of Witnesses

HEARING ON THE ANNUAL REPORT ON FEDERAL RESEARCH AND DEVELOPMENT PROGRAM FISCAL YEAR 1976

June 3, 1975:

Dr. Russell C. Drew, Director, Science and Technology Policy Office, National Science Foundation,

accompanied by Dr. John V. Granger, Executive Director, Federal Council for Science and Technology.

June 4, 1975:

Dr. Betsy Ancker-Johnson, Assistant Secretary for Science and Technology, U.S. Department of Commerce.

June 5, 1975:

Dr. T. Dixon Long, chairman, Research and Development Committee, Committee on Science and Public Policy of the American Association for the Advancement of Science, and associate professor of political science, Case Western Reserve University, Cleveland, Ohio.

accompanied by Dr. John Logsdon, member, Research and Development Committee, Committee on Science and Public Policy of the American Association for the Advancement of Science, and director, graduate program in science, technology, and public policy, George Washington University, Washington, D.C.

July 10, 1975:

Dr. Herbert I. Fusfeld, Chairman, Federal Seience and Technology Committee, Industrial Research Institute, and director of research, Kennecott Corp., New York, N.Y.

Dr. Frank H. Healey, vice president, Industrial Research Institute, and vice president, research and development, Lever Brothers Co., Edgewater, N.J.

Dr. Lewis H. Sarett, member, board of directors, Industrial Research Institute, and president, Merck Sharp & Dohme Research Laboratories, Merck & Co., Rahway, N.J.

Dr. Monte C. Throdahl, member, board of directors, Industrial Research Institute, and group vice president and director, Monsanto Co., St. Louis, Mo.

Dr. H. Guyford Stever, Chairman, Federal Council for Science and Technology, and Director, National Science Foundation.

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